PFR-1 A FULLY AUTOMATIC PROGRAMMABLE FILM READER

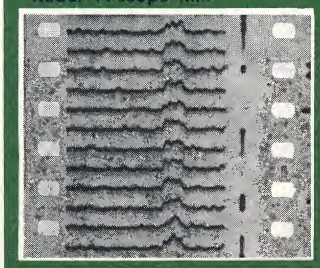
5000 POINTS PER SECOND

# PROGRAMMABLE FILM READERS

INFORMATION INTERNATIONAL INC.
200 SIXTH STREET, CAMBRIDGE, MASSACHUSETTS 02142

# PFR-1 A FULLY AUTOMATIC PROGRAMMABLE FILM READER

Radar A-scope film



. . . a high speed, completely automatic, electro-optical photo-reduction system.

. . . developed for rapid reading and digitizing of large quantities of scientific or engineering data recorded on photographic film, paper, or similar media.

# INTRODUCTION

## AN AUTOMATIC FILM READING SYSTEM

Using film as a medium for recording scientific data has many advantages. It may be used, for example, for recording oscilloscope traces, including A-scope or other radar formats; tracking pictures of missiles or aircraft (theodolite film); astronomical and meteorological data; bubble chamber data; medical data; and the like. Film is an ideal medium for recording traces of very high bandwidth (up to several thousand megacycles) which cannot be easily recorded in any other way. In addition, because of the small input power and limited storage space that are required, film is particularly suitable for recording data in space vehicles or aircraft; wind and current measuring devices; and other similar devices. However, reading or transcribing the data from film once it has been recorded has presented many problems in the past. It has generally been necessary for an analyst or researcher to read the data visually from the film and transcribe it by hand. This has been found to be a time-consuming, laborious, and relatively expensive operation. For some applications, semi-automatic film reading devices are available. However, these can read only about 5000 points per day, and require a human operator.

The Programmable Film Reader developed by Information International, Inc., is a means of automatically reading and digitizing very large quantities of photographic data. The system is operated completely under computer control and does not require a human operator. Film is read at the rate of approximately 5000 data points per second. Data output may be recorded in digital form on IBM-compatible magnetic tape for further computer processing and analysis. Other forms of output are also available.

The film reading process involves the selective scanning of film by a rapidly moving, programmable light point on a visual display cathode ray tube. The output of this scanning operation is detected by a photo sensitive device in the film reader and relayed to a scan control and monitoring unit for further processing and analysis.

The scanning technique is a significant improvement over conventional so-called "flying spot" scanning techniques. Such methods scan an entire display raster and read and store the resulting data for ALL POINTS on the raster. A large segment of computer memory is required to hold this raw data; in addition, extensive computer processing is then necessary to extract the significant data.

The Programmable Film Reader, on the other hand, is controlled by a stored computer program and is based on locating and tracking ONLY THE DATA OF INTEREST on the film. No further processing is required; the significant data is immediately available as output of the film reading system.

"Noisy" data, data superimposed on grid backgrounds, and other complex types of film data may be read effectively by means of special film reading computer programs developed for use with the Programmable Film Reader.

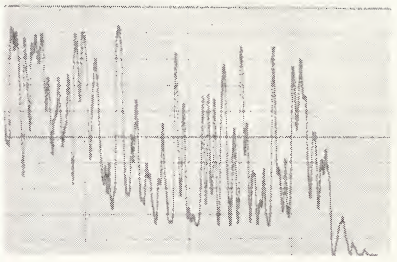
Prices of I.I.I. Programmable Film Reading Systems range from $241,000 to approximately $350,000. The system includes a Basic Film Reader, a Programmable CRT Light Source, and a Scan Control and Monitoring Unit with magnetic tape unit.

### APPLICATIONS

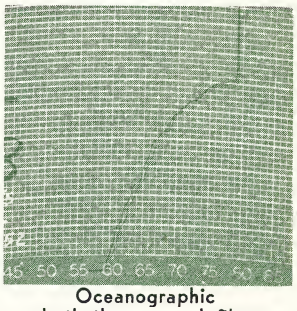
Applications of the film reading system include the reading and digitizing of radar A-scope film, including missile and aircraft tracking studies; theodolite films; ionosphere and meterological data on film; bubble chamber film; oceanographic current meter and bathythermograph film; oil well log data on film; astronomy and radio-astronomy data; and electrocardiogram and other medical film data.

I.I.I. film reading systems can read data recorded on
FILM 16, 35, 70 mm or cut film.
PAPER strip or circular charts or other similar recording media.

I.I.I. is able to supply equipment to satisfy a variety of customer needs. Customer options include transmittive or reflective input media, binary density decision, multiple level density measurement (up to 64 density levels), local contrast measurement, and various degrees of system resolution.



Oil well log film



Oceanographic bathythermograph film

# THE PFR-1 PROGRAMMABLE FILM READER

BASIC FILM READER. The Basic Film Reader contains a bi-directional transport for holding and stepping the film; and optical and electronic systems for processing film reading signals. It is composed of an Optical-Mechanical Unit and a Signal Processing and Logic Unit.

THE OPTICAL-MECHANICAL UNIT. Light coming from the CRT light-source enters the Optical-Mechanical Unit of the Basic Film Reader (see Optical Diagram, Figure 1). It is there divided into two beams by an optical beam splitter. One beam enters a Primary Optical System, passes through an enlarger and field flattener lens, and is focused on the film to be read, at a specified location corresponding to the location of the programmed light source on the CRT. The light transmitted through the film at this location passes through a set of condenser lenses, is defocused, and is sensed on the cathode of a photomultiplier tube.

The second of the two beams enters a Reference System, which does not include the film being read, passes through a neutral density filter, is similarly processed, and is sensed on the cathode of a second photomultiplier tube. The signals from the photomultipliers in both systems are amplified and compared in the Signal Processor and Logic Unit of the Basic Film Reader. Resulting digital signals are then transmitted to the Scan Control and Monitoring Unit for further processing.

As shown in the Optical Diagram, Figure 1, a Projection Subsystem is also included in the Optical-Mechanical Unit. This subsystem is not used during the film reading process itself, but rather is used as an aid in setting up film reading activities. It may be used to project an image of the film to be read upon the face of the cathode ray tube source, as an aid in making initial adjustments such as focusing and centering. As may be seen, the direction of the optical path is reversed for this purpose: a lamp in the Optical-Mechanical Unit serves as the light source; the resulting light beam then passes through the optical subsystem, including the film to be read, and projects an image of the film upon the face of the cathode ray tube.

The Optical-Mechanical Unit reads film with sprocket holes, either framed or continuously exposed. Film is automatically stepped under control of the Scan Control and Monitoring Unit. Three types of Film Transport and Objective Lens Units are available, adapted to various sizes of film to be read: 35mm (Type 1030), 16 mm (Type 1031), and 70mm (Type 1032). The film step time is less than 5 milliseconds for a complete step in either direction. Transports are available with step distance as small as 1/4 of the sprocket to sprocket distance, and as much as a single frame (4 sprocket holes in the case of 35mm film).

The Optical-Mechanical Unit contains adjustment devices for controlling:

(1) Image focus
(2) Image size
(3) Orientation angle of the film being viewed.

Film motion may be controlled automatically or manually. Control modes include fast forward or rewind, and variable speed stepping or single stepping in either direction. The Optical-Mechanical Unit also automatically monitors operating conditions such as: high voltage too high or too low; photomultipliers clipping; too much ambient light within the film reader; and other similar operating conditions.

THE SIGNAL PROCESSING AND LOGIC UNIT. The main function of the Signal Processing and Logic Unit is to process and convert analog signals from the Optical-Mechanical Unit to digital signals compatible to the Scan Control and Monitor Unit (described below); and to process and transmit signals from the SCMU for control of the OMU. Specifically, the Signal Processing and Logic Unit accepts input from the Optical-Mechanical Unit, as described above; measures density; and makes the decision whether the film at a given point is "denser" or "less dense" than a given comparison standard. It may also be used to convert the signal to "density" with up to 64 density levels available. The Signal Processing and Logic Unit protects the photomultiplier and other circuits in the Optical-Mechanical Unit by means of circuitry disconnecting the high voltage if certain limits of current or voltage are exceeded.

PROGRAMMABLE CRT LIGHT SOURCE. The standard Cathode Ray Tube Light Source has a display area of 9 3/8 inches by 9 3/8 inches containing 1024 by 1024 points. Upon designation by the Scan Control and Monitoring Unit of a specific x, y coordinate pair, or sequence of selected pairs, the CRT normally illuminates each given spot at a rate of one every 50 microseconds. Special options are available that include digitally variable intensity and dot size, as well as scan rates of up to one point every 2 microseconds.

A precision CRT is also available. The precision CRT is a special 5" tube, with a 3" x 3" display area. The dot size is approximately 1 mil (0.001 inch). It may be positioned to one of 16,384 ($2^{14}$) positions in x, and 16,384 in y, with extremely high stability. Highly accurate pin-cushion correction, using combined analog-digital techniques, is available as an option, as are digitally variable intensity and dot size.

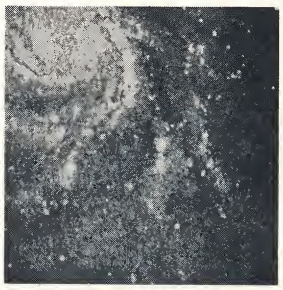
SCAN CONTROL AND MONITORING UNIT. The Scan Control and Monitoring Unit is a high speed solid state digital device designed to operate the film reading system under the guidance of an appropriate program.

The Scan Control and Monitoring Unit accepts information through input registers; controls the positioning of the light point; and controls the scanning actions and the film advance.

Auxiliary equipment includes a magnetic tape transport and a magnetic tape control. The magnetic tape is completely compatible with IBM tape formats.

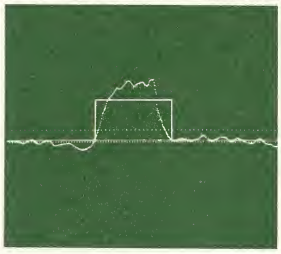
ADDITIONAL OPTIONS. Local contrast measurement circuitry is available as an option. This allows the comparison of the density of a specific point on the film with the density of a surrounding area (a disc with the specific point as center). In this way, it is possible to detect areas of increasing or decreasing density.

As an additional option, the system may be used to determine the density of film being read over a grey scale of up to 64 possible values.

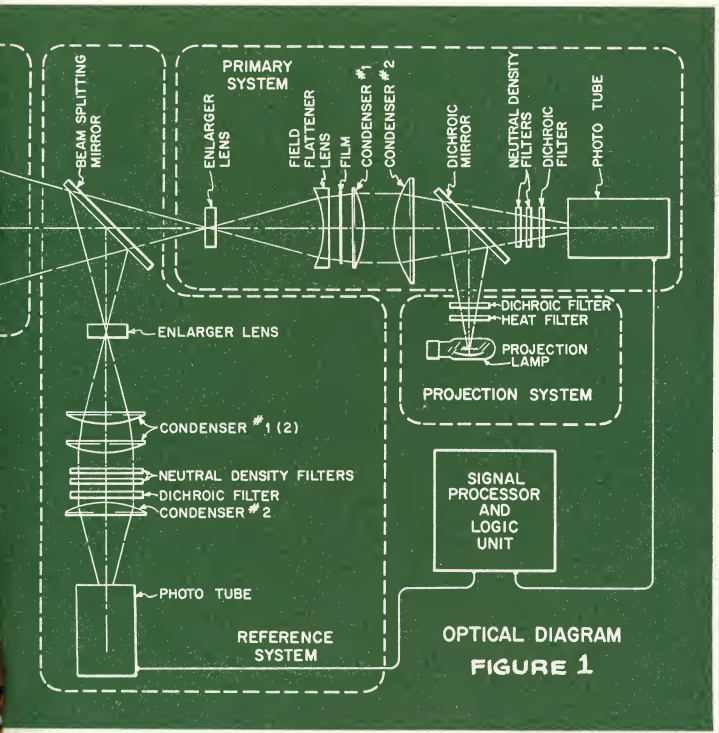


Star chart and satellite tracking film

Oceanographic current meter film



Scope display of radar A-scope film reading program




OPTICAL DIAGRAM

FIGURE 1

## MISSILE TRACKING STUDIES

Information International has recently developed a film reading system to read data representing missile tracking studies recorded in the form of A-scope radar pulses on 16, 35, and 70mm film. The film reading system has the following capabilities:

(1) Approximately 500 readings per frame of the amplitude of the radar signals

(2) Computation of the median amplitude value for each frame

(3) Count of the number of radar pulses

(4) Measurement of each radar pulse width, average amplitude, and location of the leading edge of the pulse

(5) Recording on IBM-compatible magnetic tape in digital form of all original and processed data.

## OCEANOGRAPHIC CURRENT METER FILM

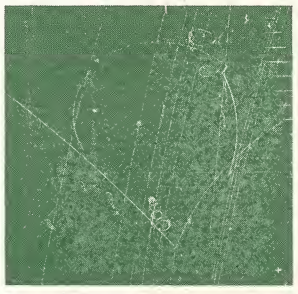
Information International has also developed a similar system to read data recorded on film by oceanographic current meters. These current meters are located in specific oceanic areas. They contain devices for automatically recording on film information such as the direction and rate of flow of ocean currents. Data is recorded in the form of interrupted lines or bars on 16mm film. The film reading system scans and analyzes this data. Output is recorded on magnetic tape in the form of digital values of the speed and direction of the ocean currents.

# THE PFR-2 PRECISION PROGRAMMABLE FILM READER

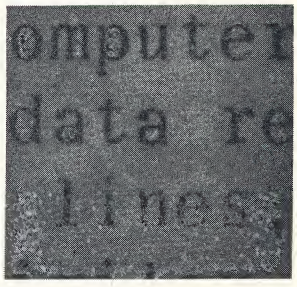
The PFR-2 Precision Programmable Film Reader may be used to read images on film or glass plates to an accuracy of 5 microns. The system is based on a positional reference feedback technique that will allow positions of images to be determined with respect to a highly accurate reference grid. The film holder now in use is suitable for cut film negatives 5" x 5" or smaller; e.g., 4" x 5", 2¼" x 3½", or 35mm cut film. The system makes use of a small field of high precision measurement, 0.2" x 0.2". This field may be rapidly brought to bear on all portions of the film to be read, by means of a mechanical digital x-y positioner. The film is moved in steps of 0.05 inch in x and in y. The average repositioning speed is 5 milliseconds per step. The dot size at the light source on the film is 0.0001 inch, or approximately 2.5 microns, in diameter. Nominal distance between two adjacent points is approximately 0.000013 inch. This allows reading well defined images to an accuracy of 0.0002 inch (about 5 microns) or better.[1]

The PFR-2 Precision Programmable Film Reader combines, for the first time, extremely high resolution with a rapid processing rate. For this reason, it is particularly well suited to the rapid and automatic reduction of astronomical star plates, satellite tracking, bubble chamber film, automated map making, reading of engineering drawings, and other similar applications requiring a very high degree of optical resolution. It was initially developed for the analysis of film records consisting of electrical transients of several thousand megacycle bandwidth recorded as oscilloscope traces.

1. The sum total of all system errors is such as to allow the measurement of the position of a well defined image with an error of less than .0002 inch in x and in y. This means that the measurement of the relative position of images will never vary from the true position by more than .0002 inch in x and in y. This accuracy is normally available over a 0.8 x 0.8 inch square, but it is available for areas up to 8 inches by 8 inches.



Bubble chamber film



Character recognition

## FILM READING PROGRAMS

The film reading program which governs the automatic scanning and analysis of film is one of the most important parts of an I.I.I. film reading system. I.I.I. has an extensive library of film reading control programs and associated subroutines available for application to specific problems, built up over several years of providing film reading systems and services on a commercial basis. In many cases, effective film reader control programs for special applications can be created by a combination or modification of existing programs.

Available routines include a selection of "microscope" scans that examine a small portion of an image on film and display it back in a magnified form revealing minute detail and density variations. A "polar" scan routine is available for scanning data presented against a polar coordinate grid. An entire family of radar scan programs are available which can automatically scan radar A-scope traces, either alone or against a background of horizontal (baseline) or vertical (timing mark) lines, and store the digitized trace data on magnetic tape. More generally, these programs are able to scan traces of the form $y = f(x)$ where $f(x)$ is a single-valued function. Signal detection schemes are incorporated in many of these programs to permit efficient scanning of traces in low signal to noise regions.

A special class of routines is available for scanning data stored on film in the form of multiple on-off (binary) channels. The programs are flexible, providing for a variable number of channels and variable channel positions. Signal detection schemes are incorporated to assist in recognition of channels and recognition of pulses in the presence of high noise levels.

A complete selection of programs will shortly be available for automatically scanning multiple-valued functions. These programs will contain highly sophisticated topological and statistical schema for scanning, tracking, and digitizing the functions.

## SOLVING FILM READING PROBLEMS: A SYSTEMS APPROACH

Information International has had considerable experience in the design of film reading systems to read photographic data reliably and accurately. The firm specializes in solving clients' film reading problems by supplying completely set-up, ready-to-run film reading systems. I.I.I. can also provide a basic film reading device, appropriate film reading programs, and technical consulting to those planning to develop their own film reading systems. Our present customers include:

AIR FORCE MISSILE DEVELOPMENT CENTER
Holloman Air Force Base, New Mexico

WHITE SANDS MISSILE RANGE
New Mexico

RADIO CORPORATION OF AMERICA
Missiles and Surface Radar Division
Moorestown, New Jersey

M.I.T. LINCOLN LABORATORY
Lexington, Massachusetts

BELL TELEPHONE LABORATORIES
Whippany, New Jersey

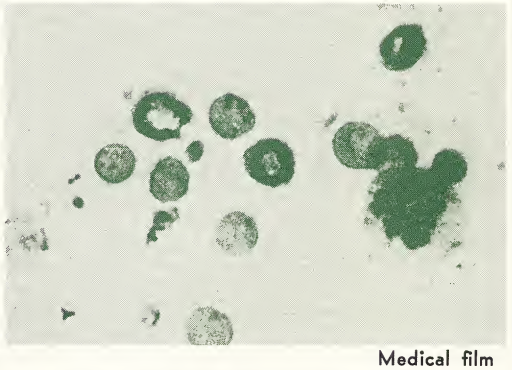
U.S. PUBLIC HEALTH SERVICE
Washington, D.C.

WOODS HOLE OCEANOGRAPHIC INSTITUTE
Woods Hole, Massachusetts

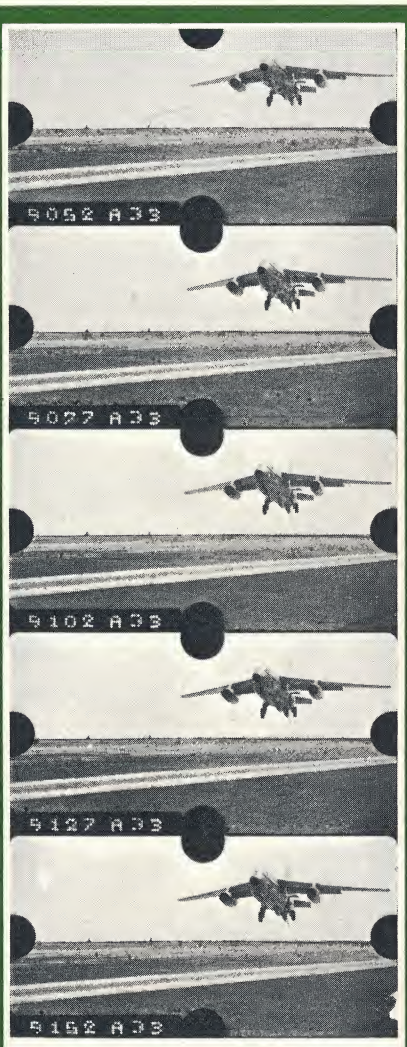
LAWRENCE RADIATION LABORATORY
University of California
Livermore, California

HARVARD UNIVERSITY
Cambridge, Massachusetts

EDGERTON, GERMESHAUSEN AND GRIER, INC.
Las Vegas, Nevada



Medical film




Cine-theodolite film

70mm ½ frame 4 digit time and 3 digit alphanumeric event (carrier landing sync rate study — NAEC, Phila.)

## FILM READING SERVICE

In cases where workload does not warrant purchase of a film reading system, I.I.I.'s film reading service is available for reading and digitizing film. Film may be mailed to the firm; data on the film will be digitized in a suitable format, and recorded on IBM-compatible magnetic tape for further processing. Magnetic tape and film are then returned to the client. Use of air mail, together with rapid processing turn-around time, make the film reading service particularly effective for rapidly digitizing large quantities of scientific data on film. Prices for film reading services are available on request.

## MODULES FOR PHOTOMULTIPLIER APPLICATIONS

An integrated set of modules is available for use in a variety of photomultiplier applications where temperature stability, reliability, sensitivity, and dynamic range are major considerations. Present applications include nuclear research, medical diagnostics, industrial process control, radio astronomy, oceanography, and aerospace tracking. Included in the set are a photomultiplier preamplifier (PA-3), dual log amplifier (LA-1), dual AC coupled emitter follower (AC-1), gated operational integrator with operational inverter (INT-1), two-state difference detector (DA-4), and inexpensive dual two-state difference detector (DA-2).

A three-state difference detector, designated model DA-6, employs a Darlington connected, differential preamplifier. It features high common mode rejection, and a variable threshold capability. Three logic level outputs correspond to less than, equal to, or greater than comparisons of the input signals.

Please write for further information.

For more detailed information or custom applications, ref. technical brochure 100 and contact:

**INFORMATION INTERNATIONAL INC.**
200 SIXTH STREET, CAMBRIDGE, MASSACHUSETTS 02142 (617) 868-9810

**INFORMATION INTERNATIONAL INC.** *200 Sixth Street, Cambridge, Massachusetts, 02142 ▪ Tel (617) 868-9810*

February 15, 1965

Mr. T. Nelson
System Consultant
Box 1546
Poughkeepsie, New York

Dear Mr. Nelson:

Thank you for your interest in Information International, Inc. and our Programmable Film Reader. I have enclosed some literature for your information.

Essentially, this equipment provides a capability of automatically extracting data from film at high speed and translating it into a form which can be processed digitally. The application areas include almost any data which can be put on film and read by a human. These include, for example, oscilloscope traces, cinetheodolite data, aerial and satellite photographs, microphotographs, and many others. Data currently recorded on media other than film, such as paper strip charts, can also be microfilmed for automatic reading and convenient permanent storage.

The equipment is available on an outright sale or on a service basis. We will quote for film reading on a per reel basis, upon receipt of a sample of film and a description of the data to be extracted.

We can demonstrate the equipment to you at your convenience at our location.

I will be pleased to provide any further information of interest to you and look forward to hearing your reaction to the availability of this new capability.

Very truly yours,

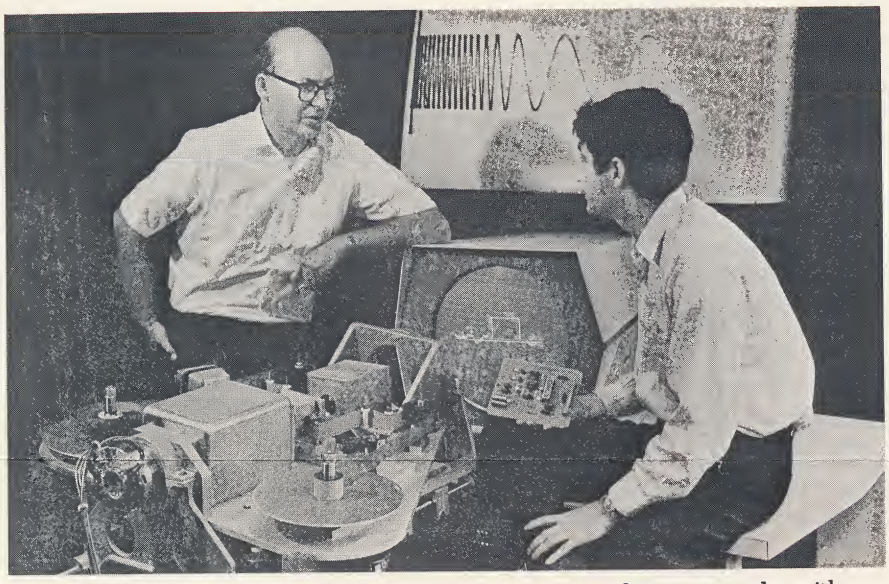
Philip F. Dolan

Philip F. Dolan

PFD:jl
enc.

BW BUSINESS WEEK

REPRINTED FROM ISSUE OF: September 19, 1964



**Edward Fredkin** (right), head of Information International, Inc., consults with M. L. Minsky, company director and leader in artificial intelligence work at MIT.

NEW PRODUCTS

# Eye for computers is quick as a wink

**That, in essence, is the function of the Programmable Film Reader. For industry and the military, it does in a second what older equipment took a whole day to accomplish**

**The fleeting image** traced by an electron beam on a radar screen can be captured on film, but the process of translating that film record into a form that can be fed into a computer has been about as slow as the electron beam is fast.

Now that situation is being changed by a new machine, whose heart lies in the reels and lens shown in front of the cathode ray tube (picture). What it does is remove a serious bottleneck from the process of transferring data ranging from blood cell counts to missile shots into a form that machines can use.

The device, called the Programmable Film Reader, can continuously read 5,000 points per second; previously, film reading devices were doing well if they read that many points in a whole day—and they needed the services of an operator. Laboratories have built a few extremely fast film readers for special purposes. One, at the University of California's Radiation Laboratory in Berkeley, reads bubble chamber tracks from film so fast that it is hooked directly to a very large scale computer. But the California machine is, so far, strictly one of a kind.

**One-man show.** The PFR is made by small but fast-growing Information International, Inc., of Cambridge, Mass. Just two and a half years ago, its 29-year-old president, Edward Fredkin, left a Boston programming company to open his one-man business. Already, he has parlayed his ideas into a company that cleared almost 10% on sales of $1-million in its second year. This year it's looking forward to sales of $4-million.

Most of the company's hopes are based on the PFR, which sells in a range from $100,000 up to nearly $300,000 and adds astronomical, medical, oceanographic, and biological film-reading to the military applications for which it was designed. Just the last three months, four machines have been ordered, valued at $1,350,000.

The company got into manufacturing quite by accident, after starting out to provide sophisticated programming services. MIT's Lincoln Laboratory needed to analyze miles of movie film from studies of missile tracking; it called on Information International for help.

Fredkin and his associates soon devised a system built around a rented movie camera. But they hacked up the camera so badly in the process that they had to buy it. And the end product, which had been intended merely as a feasibility demonstration, pleased the people at Lincoln so much that they wouldn't let it go.

**Missile base.** Soon after that, the Air Force heard about the machine and ordered a production model for its missile development center at Holloman Air Force Base, in New Mexico. Most subsequent orders have come from sophisticated customers who have seen the Holloman model. The latest and most accurate model can read high-density data from atomic test films to an accuracy of better than one-two thousandths of an inch.

The secret of the Programmable Film Reader is reflected in its name. It reads film with a light source that is directed by a computer. Thus it isn't necessary to scan the entire film; as Fredkin puts it: "We look at what's important and then follow it."

The computer program is crucial to the operation of the machine. And because Information International believes in a systems approach, it will not take an order for a reader unless it also supplies a program for the computer. "After we deliver the machine, the company can go ahead and write a different program," says Pres. Fredkin. "But at least we know that they have a setup that will work."

# REQUEST FOR PRICE QUOTATION

**PROGRAMMABLE FILM READING SYSTEMS AND SERVICES**

**INFORMATION INTERNATIONAL INC. 200 SIXTH STREET**
**CAMBRIDGE, MASSACHUSETTS 02142 TEL. (617) 868-9810**

**COMPANY NAME AND ADDRESS**

RFQ NUMBER

DATE

SALESMAN

**CONTACT FOR FURTHER INFORMATION** TELEPHONE

**QUOTE REQUESTED FOR**
- ☐ FILM READING SYSTEM
- ☐ FILM READING SERVICE

**BRIEF DESCRIPTION OF APPLICATION**
(CONTINUE ON OTHER SIDE, IF NECESSARY)

**FILM CHARACTERISTICS** (PLEASE ATTACH SAMPLE OF FILM)

**SIZE**
- ☐ 16 MM
- ☐ 35 MM
- ☐ 70 MM
- ☐ OTHER:

**SPROCKETED**
- ☐ YES
- ☐ NO

**APPROXIMATE NO. OF FEET ON FILM REEL:**

**DATA OF INTEREST ON FILM**
(CONTINUE DESCRIPTION ON OTHER SIDE, IF NECESSARY)

**QUANTITY OF FILM PRESENT BACKLOG**
(IF ANY):

**PRESENT RATE OF FILM ACCUMULATION:**
- ☐ MONTHLY
- ☐ WEEKLY

**ANTICIPATED RATE OF FILM ACCUMULATION:**
- ☐ MONTHLY
- ☐ WEEKLY

**TYPE OF OUTPUT DESIRED**
(MAGNETIC TAPE, CARDS, PAPER TAPE, ETC.)

**DUE DATE OF QUOTATION**